

High-Flux Dialysis Membrane with Improved Separation Behaviour

Claims

1. A hydrophilic, water-wettable, semipermeable hollow-fibre membrane, based on a synthetic first polymer, particularly for hemodialysis, hemodiafiltration and hemofiltration, the membrane possessing an open-pored, integrally asymmetric structure across its wall, a porous separating layer with a thickness of 0.1 to 2 μm on its inner surface facing the lumen, and an open-pored supporting layer adjoining the separating layer, and having an ultrafiltration rate in albumin solution in the range of 25 to 60 $\text{ml}/(\text{h}\cdot\text{m}^2\cdot\text{mmHg})$, characterised in that, after prior drying, the hollow-fibre membrane has a minimum sieving coefficient for cytochrome c of 0.8 combined with a maximum sieving coefficient for albumin of 0.005, whereby the hollow-fibre membrane in the dry state is free from pore-stabilising additives in the membrane wall.
2. Hollow-fibre membrane according to Claim 1, characterised in that it also comprises a hydrophilic second polymer.
3. Hollow-fibre membrane according to Claim 1, characterised in that the synthetic first polymer is a hydrophobic first polymer and the hollow-fibre membrane also comprises a hydrophilic second polymer.
4. Hollow-fibre membrane according to Claim 3, characterised in that the hydrophobic first polymer is an aromatic sulfone polymer such as polysulfone,

polyethersulfone, polyphenylenesulfone or polyarylethersulfone, a polycarbonate, polyimide, polyetherimide, polyetherketone, polyphenylene sulfide, or a copolymer or a modification of these polymers, or a mixture of these polymers.

5. Hollow-fibre membrane according to Claim 4, characterised in that the hydrophobic first polymer is a polysulfone or a polyethersulfone.
6. Hollow-fibre membrane according to one or more of Claims 2 to 5, characterised in that the hydrophilic second polymer is polyvinylpyrrolidone, polyethylene glycol, polyvinyl alcohol, polyglycol monoester, polysorbate, carboxymethylcellulose, or a modification or copolymer of these polymers.
7. Hollow-fibre membrane according to one or more of Claims 1 to 6, characterised in that the supporting layer extends from the separating layer across essentially the entire wall of the hollow-fibre membrane, has a sponge-like structure and is free from finger pores.
8. Hollow-fibre membrane according to one or more of Claims 1 to 7, characterised in that it has a minimum sieving coefficient for cytochrome c of 0.85.
9. Hollow-fibre membrane according to one or more of Claims 1 to 8, characterised in that it has a maximum sieving coefficient for albumin of 0.003.
10. Hollow-fibre membrane according to one or more of Claims 1 to 9, characterised in that a polyelectrolyte with negative fixed charges is physically bound in the separating layer.
11. Hollow-fibre membrane according to one or more of Claims 1 to 10 with an ultrafiltration rate in albumin solution in the range of 30 to 55 ml/(h·m²·mmHg).

12. Method for producing a hydrophilic, water-wettable, semipermeable hollow-fibre membrane according to Claim 1, the method comprising the following steps:

- a. preparing a homogeneous spinning solution comprising 12 to 30 wt.% of a synthetic first polymer and, if applicable, other additives in a solvent system,
 - b. extruding the spinning solution through the annular slit of a hollow-fibre die to give a hollow fibre,
 - c. extruding an interior filler through the central opening of the hollow-fibre die, the interior filler being a coagulation medium for the synthetic first polymer and comprising a solvent and a non-solvent for the synthetic first polymer,
 - d. bringing the interior filler into contact with the inner surface of the hollow fibre, to initiate coagulation in the interior of the hollow fibre and for formation of a separating layer on the inner surface of the hollow fibre and formation of the membrane structure,
 - e. passing the hollow fibre through a coagulation bath to complete the formation of the membrane structure if necessary, and to fix the membrane structure,
 - f. extracting the hollow-fibre membrane thus formed, to remove the solvent system and soluble substances,
 - g. drying the hollow-fibre membrane,
- characterised in that the interior filler contains a polyelectrolyte with negative fixed charges, as a result of which a hollow-fibre membrane is obtained with a minimum sieving coefficient for cytochrome c of 0.80 combined with a maximum sieving coefficient for albumin of 0.005.

13. Method according to Claim 12, characterised in that the spinning solution also comprises 0.1 to 30 wt.% of a second hydrophilic polymer.

14. Method according to Claim 12, characterised in that the synthetic first polymer is a hydrophobic first polymer and the spinning solution also comprises 0.1 to 30 wt.% of a hydrophilic second polymer.
15. Method according to Claim 14, characterised in that an aromatic sulfone polymer such as polysulfone, polyethersulfone, polyphenylenesulfone or polyarylethersulfone, a polycarbonate, polyimide, polyetherimide, polyetherketone, polyphenylene sulfide, a copolymer, a modification of these polymers, or a mixture of these polymers is used as the hydrophobic first polymer.
16. Method according to one or more of Claims 13 to 15, characterised in that polyvinylpyrrolidone, polyethylene glycol, polyvinyl alcohol, polyglycol monoester, polysorbate, carboxymethylcellulose, or a modification or copolymer of these polymers is used as the hydrophilic second polymer.
17. Method according to one or more of Claims 12 to 16, characterised in that the solvent system comprises a polar aprotic solvent.
18. Method according to one or more of Claims 12 to 17, characterised in that the polyelectrolyte is selected from the group of polyphosphoric acids, polysulfonic acids or polycarboxylic acids.
19. Method according to Claim 18, characterised in that the polycarboxylic acids are homo- or copolymers of acrylic acid.
20. Method according to one or more of Claims 12 to 19, characterised in that the proportion by weight of the polyelectrolyte relative to the weight of interior filler is 0.01 to 1 wt.%.